US Army Corps
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Station

Zebra Mussel Research Technical Notes

Section 2 — Control Methods **Technical Note ZMR-2-07**

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Corrosion Rates of Ferrous Metals Associated with Zebra Mussel Infestations

Purpose

The purpose of this technical note is to discuss the mechanisms and rates of zebra mussel-assisted corrosion of ferrous metal surfaces. This information allows facility managers to better gauge the impact of the zebra mussel.

This technical note replaces the earlier Technical Note ZMR-2-07, which should be discarded.

Additional information

This technical note was prepared by personnel of the U.S. Army Construction Engineering Research Laboratories. For more information, contact Mr. Tim Race, (217) 373-6769, e-mail *t-race@cecer.army.mil.* Dr. Ed Theriot, U.S. Army Engineer Waterways Experiment Station, (601) 634-2678, is Manager of the Zebra Mussel Research Program.

Corrosion mechanisms

It has been generally agreed within the literature that macrofouling will facilitate corrosion of metallic surfaces. Biologically facilitated corrosion may occur as a result of oxygen and ion concentration cells that may in turn result in the formation of anodic and cathodic sites on the metallic surface.

Iron bacteria oxidize ferrous iron to form ferric hydrate. Ferric hydrate deposition can lead to tubercle formation, resulting in oxygen concentration cell corrosion. The corrosivity of these cells may be enhanced by the presence of sulfate-reducing bacteria that can proliferate under the anaerobic conditions associated with macrofouling. The presence of ferrous sulfide in corrosion products is evidence of biologically facilitated corrosion.

Water samples taken from within the zebra mussel mat at Black Rock Lock, Buffalo, New York, were cultured and found to contain significant quantities of both iron and sulfate-reducing bacteria (Myers and McWhirter 1993). Corrosion products collected from beneath the zebra mussel mat were analyzed by energy-dispersive x-ray analysis and found to contain sulfur. Microchemical analysis of the corrosion products confirmed the presence of ferrous sulfide. These results suggest that zebra mussels at Black Rock Lock

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provide conditions conducive to the occurrence of microbiologically induced corrosion.

Measurements of structure-to-steel potentials were taken on sheet pile walls at Black Rock Lock in Buffalo, NY, and at O'Brien Lock and Dam in Chicago, IL (Myers and McWhirter 1993, CC Technologies Laboratories 1995). The results of these measurements indicate cathodic and anodic sites consistent with oxygen concentration cells and anaerobic corrosion.

Corrosion rates

A study conducted by the Naval Research Laboratory found a nearly constant corrosion rate of 2.7 mils per year (mpy) for mild steel in fresh water under anaerobic conditions with anaerobic bacteria present (Simkins and Jones 1993). Other values reported in the literature for corrosion of steels in anaerobic environments range from 10 to 76 mpy depending on the alloy and service environment (CC Technologies Services, Inc. 1995).

In a study conducted for Public Works and Government Services Canada, maximum pitting rates associated with zebra mussel fouling on sheet pile piers on the St. Lawrence River were found to be 2.5 to 3.0 mm for a 3-year period or 33 to 39 mpy (MIE Consulting Engineers, Ltd. 1994).

In another study, conducted for the U.S. Army Corps of Engineers, corrosion pit depths were measured on a barge ring found at Black Rock Lock (Myers and McWhirter 1994). The barge ring was found in a flat position on the channel bottom such that only one side was colonized with zebra mussels. Maximum pit depths for the colonized and uncolonized sides of the ring were 90 and 43 mils, respectively. Assuming that the ring had been exposed and colonized since the inception of the zebra mussel infestation in the Niagara River (approximately 1990), a pitting corrosion rate of approximately 11.8 mpy is calculated. Changing the assumed period of time that the ring was exposed to just 2 years would indicate a pitting rate of 23.5 mpy.

In another study conducted for the Corps of Engineers, corrosion pit depths were measured on zebra mussel-colonized stainless and mild steel test coupons at Black Rock Lock (CC Technologies Services, Inc. 1995). No pitting of the stainless steel substrate (less than 0.5 mil detection level) was observed, while pit depths of 9 to 29 mils were measured on the mild steel coupon. The corresponding rate of pitting corrosion of mild steel is 10 to 32 mpy. Linear polarization resistance (LPR) was used to perform instantaneous average corrosion rate measurements on the test coupons. Corrosion rates of about 0.16 and 3.8 mpy were measured for stainless and mild steels, respectively. The values obtained by LPR represent an average of the overall corrosion rate for the entire surface of the test coupons. Not surprisingly, the corrosion rate for mild steel is less than calculated from the pit depth data. It should not be inferred from these data that stainless steels are immune from microbial corrosion. These is evidence in the literature that stainless steel could be subject to microbial corrosion under anaerobic conditions.

Zebra mussels do not appear to accelerate the rate of general corrosion appreciably. However, the rate of pitting corrosion beneath

zebra mussels is significantly higher than would normally be expected, probably in the range of 10 to 30 mpy.

Implications of accelerated corrosion

Accelerated corrosion may reduce the life expectancy of some structures or their components. Some items, such as hydraulic lines, may be particularly prone to premature failure from perforation caused by pitting corrosion. Structural members, such as gate support beams, could be weakened by the loss of cross-sectional thickness caused by pitting corrosion. Steel sheet piling is most likely to be affected by zebra mussel-related corrosion below the waterline in the area of maximum bending stresses (MIE Consulting Engineers, Ltd. 1994).

Accelerated corrosion may also increase maintenance requirements and corrosion prevention costs. Items not traditionally protected from corrosion, such as steel sheet piling, may require protective coatings or cathodic protection. Other items may require more frequent painting to sustain a given level of corrosion protection. Some critical items may need to be protected through the use of zebra mussel control technologies, such as biocides or thermal treatment.

Recommendations

Ferrous metal structures and components likely to be fouled by zebra mussels should be designed with an understanding of the added potential for severe corrosion problems. Steel sheet piling and stainless steel construction may be particularly susceptible to the effects of accelerated corrosion because they are typically left unprotected. Painting of sheet pile and stainless steel construction should be considered. More frequent inspection or replacement of protective coating systems may be warranted.

References

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